

# India's Energy Potential and Scope for LBNL Activities

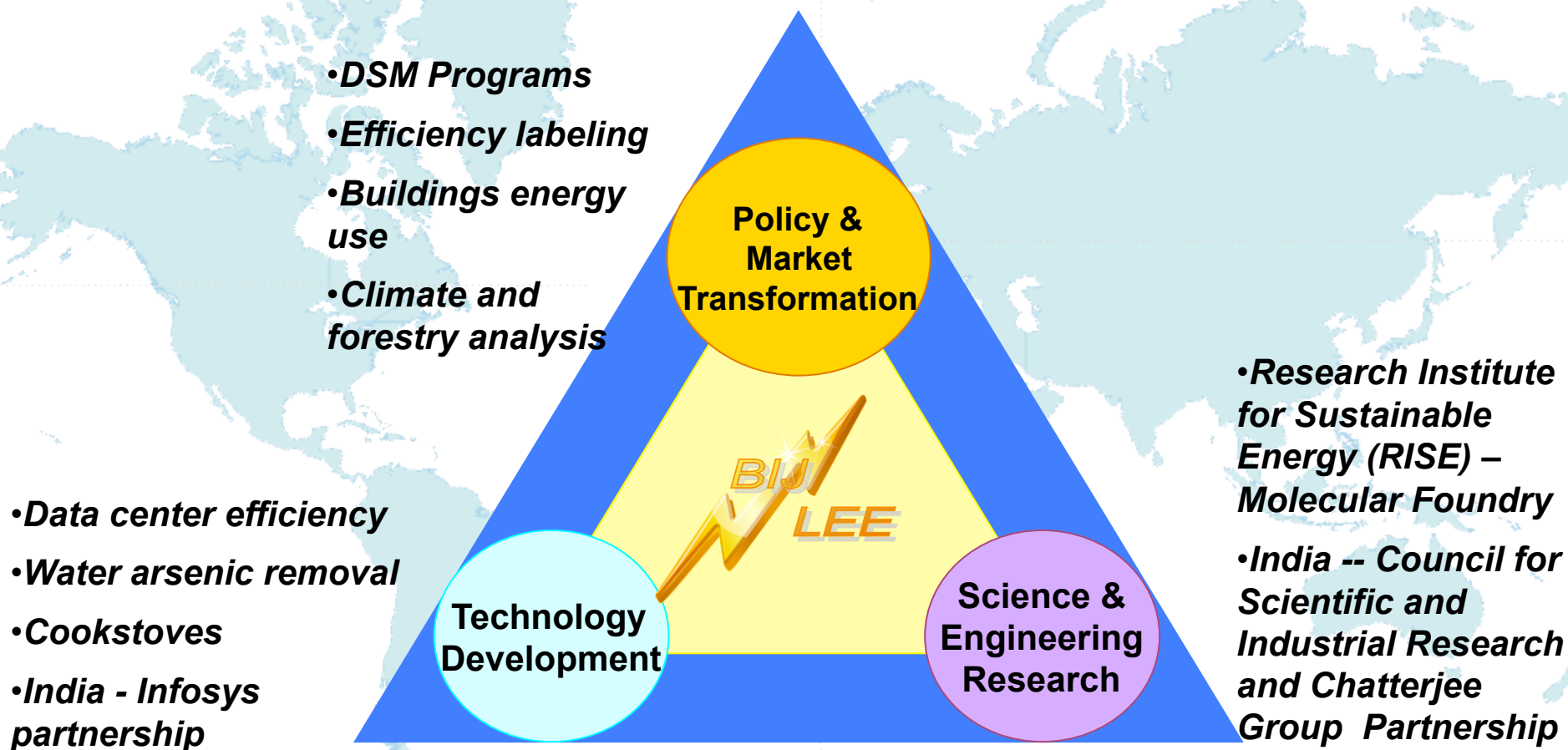
19 October 2010

**Jayant A. Sathaye**  
**Leader, International Energy Studies Group**

with slides from  
Stephane de la Rue du Can, Amol Phadke, Girish Ghatikar, and Phil Haves

# Berkeley India Joint Leadership on Energy and Environment (BIJLEE)

Initiated on October 3, 2008 by Director Chu and Chancellor Birgeneau



# Berkeley – India Activities



- **GHG Reduction Potential and Cost Data and Analysis**

- **Energy and Forestry Sectors**
- **Data and Analysis**

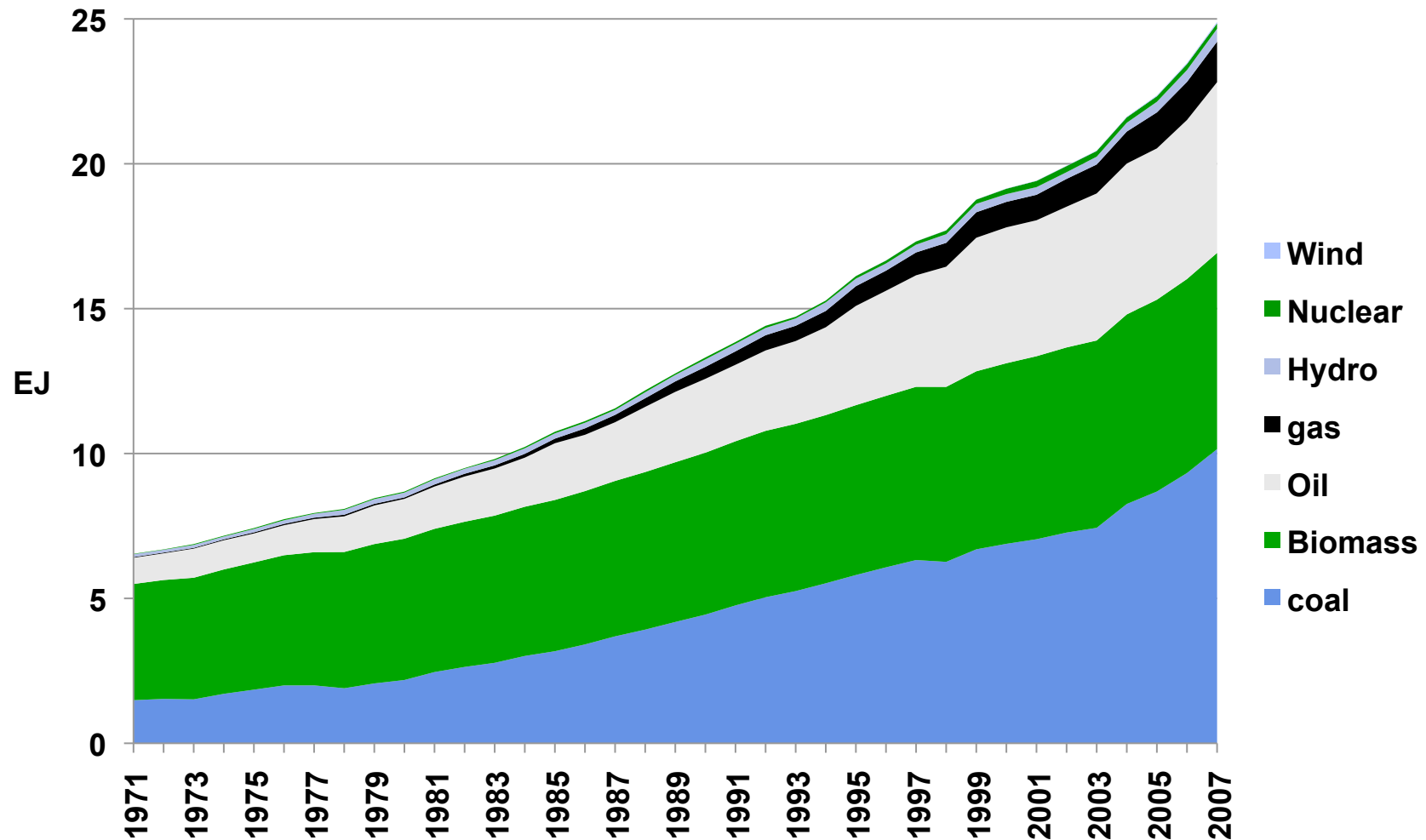
- **R&D, Technology, Policy and Implementation**

- **Energy Efficiency**
  - **Power Sector**
  - **Data Centers**
  - **Buildings**
  - **White Roofs**
  - **Industry**
- **Renewable Energy**



• DOE, State Dept, EPA, Climate Works  
Foundation, World Bank, Infosys, Metro Valley  
Other companies

# India Primary Energy Consumption (1.1 billion population)

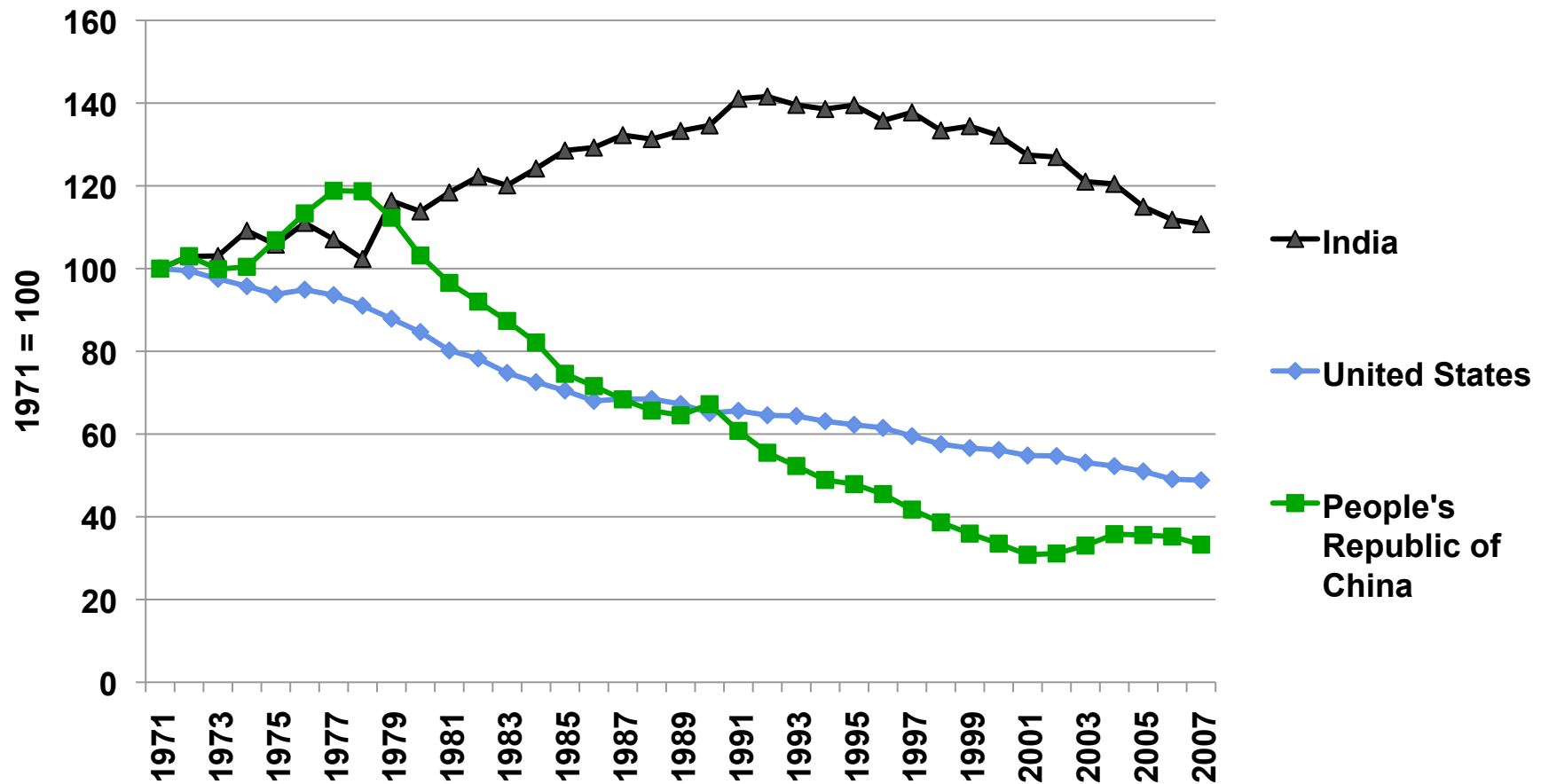




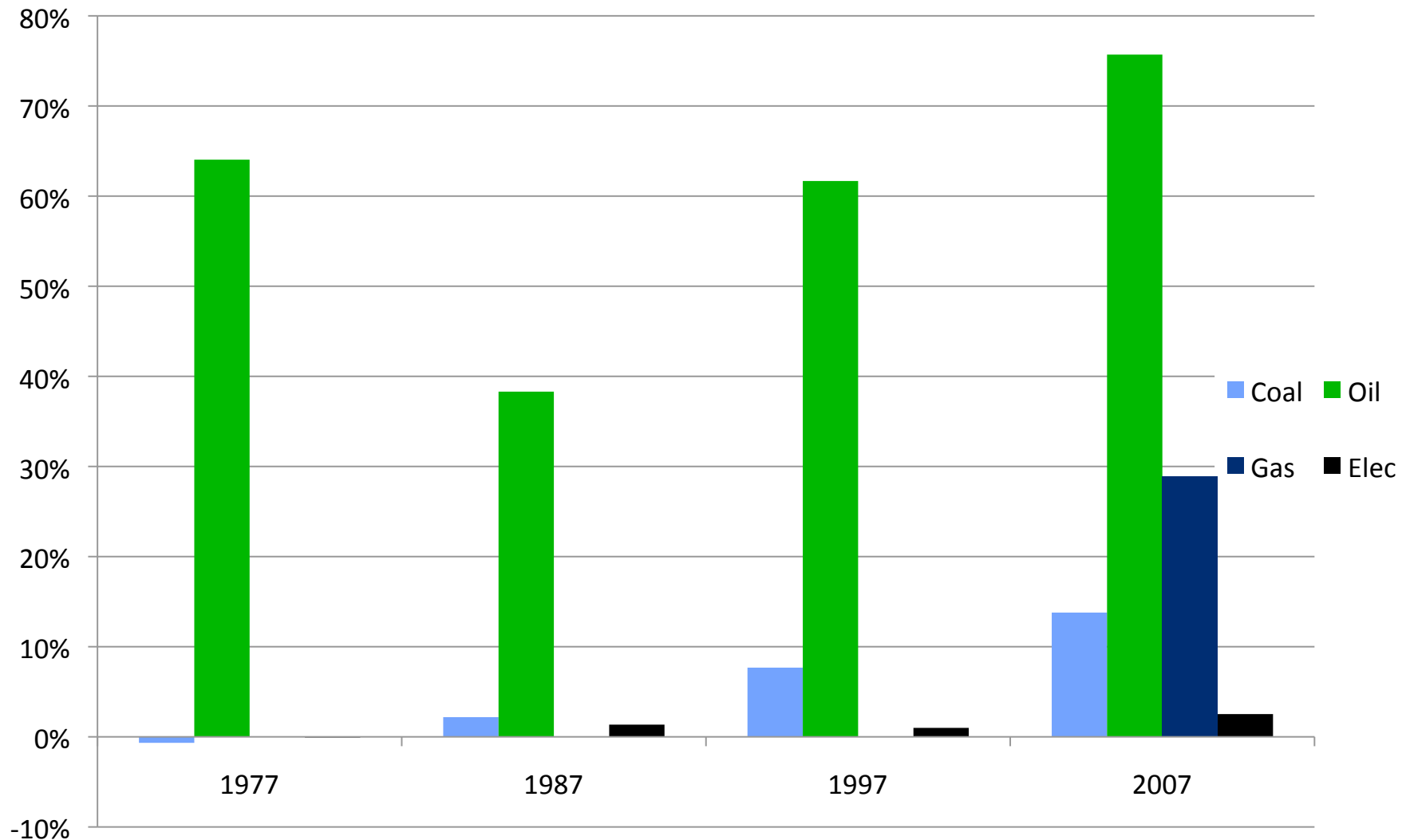
# Declining Energy Intensity



**Primary Energy Supply /GDP**  
(PJ/2000 US \$; Excl. traditional biomass Indexed to 1971=100)



# Net Imports (% of Primary Energy Consumption)

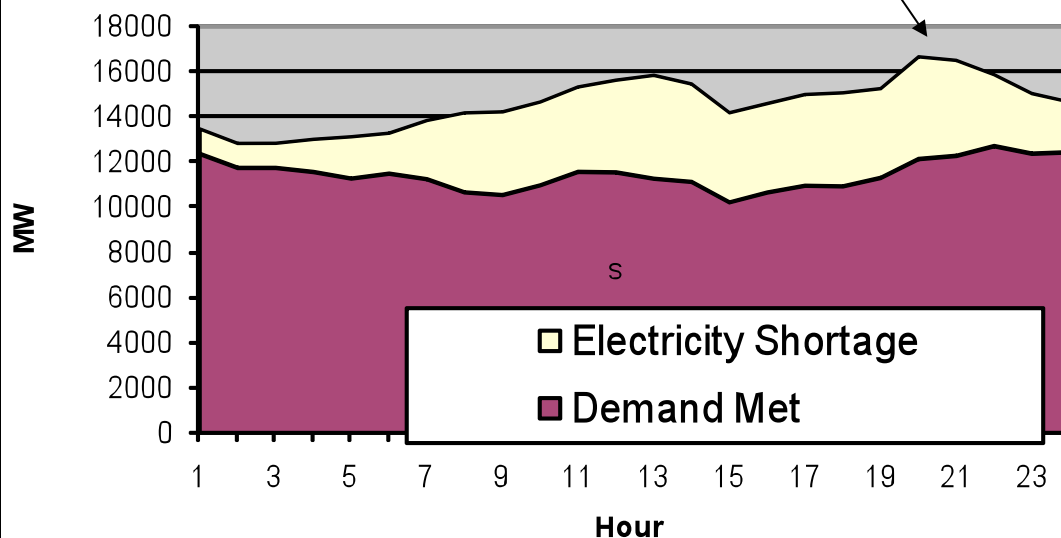


# Chronic Electricity Shortages

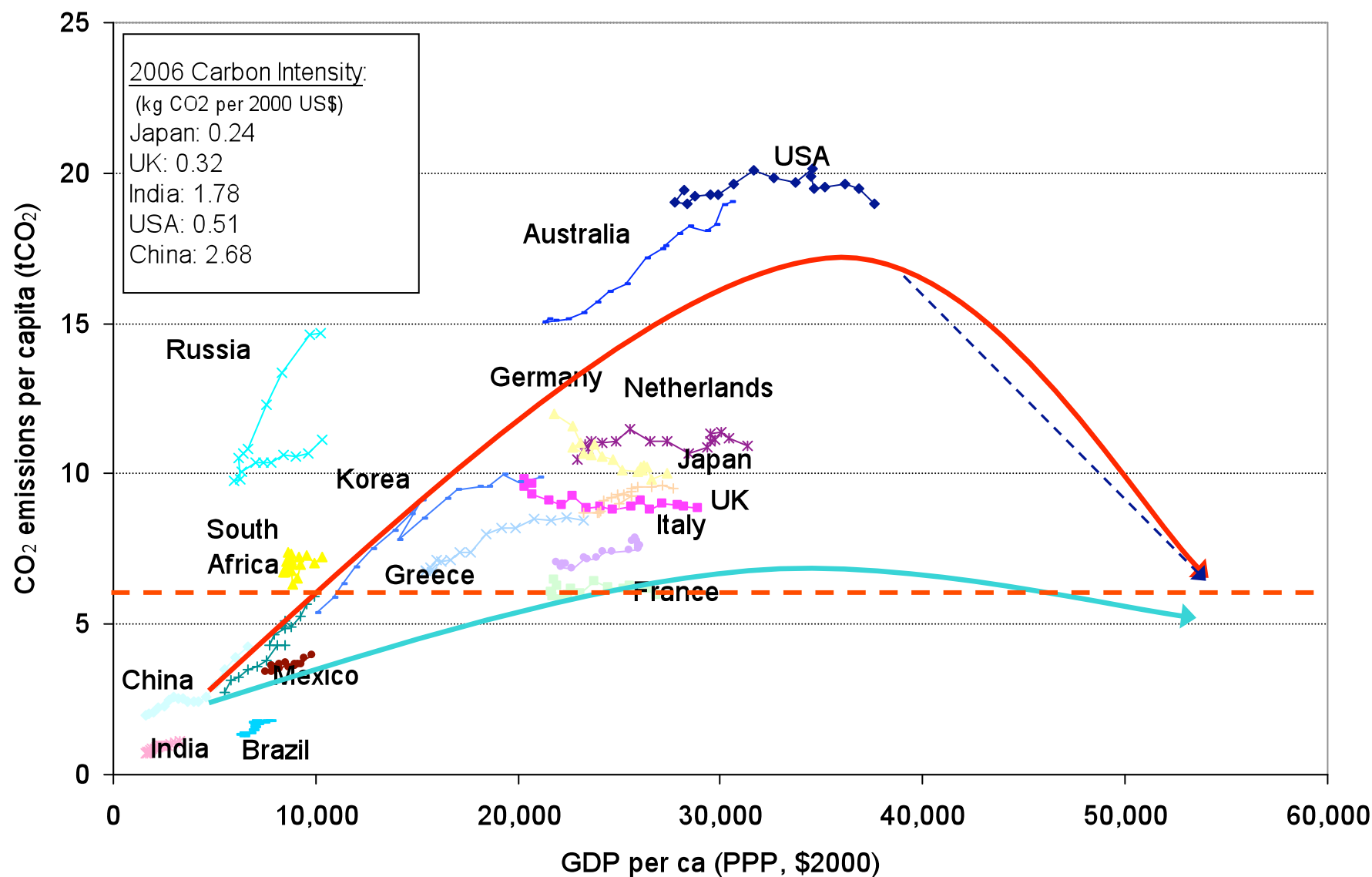
*National Scale: Peak Power Deficit – 12%;  
Electricity Deficit – 8%*

**29% peak shortage**

**Maharashtra State April 28th, 2008**



## CO<sub>2</sub> Emissions of Selected Countries



# India's National Action Plan on Climate Change (NAPCC) – 2008



Mission	Objective	Responsible Entity
<i>National Solar Mission</i>	• 20,000 MW of solar power by 2020	Ministry of New & Renewable Energy
<i>National Mission for Enhanced Energy Efficiency</i>	• 10,000 MW of EE savings by 2020	Ministry of Power
<i>National Mission for Sustainable Habitat</i>	• EE in residential and commercial buildings, public transport, Solid waste management	Ministry of Urban Development
<i>National Water Mission</i>	• Water conservation, river basin management	Ministry of Water Resources
<i>National Mission for Sustaining the Himalayan Ecosystem</i>	• Conservation and adaptation practices, glacial monitoring	Ministry of Science & Technology
<i>National Mission for a Green India</i>	• 6 mn hectares of afforestation over degraded forest lands by the end of 12 <sup>th</sup> Plan	Ministry of Environment & Forests
<i>National Mission for Sustainable Agriculture</i>	• Drought proofing, risk management, agricultural research	Ministry of Agriculture
<i>National Mission on Strategic Knowledge for Climate Change</i>	• Vulnerability assessment, Research & observation, data management	Ministry of Science & Technology

Missions focused on 'Mitigation'
  Missions focused on 'Adaptation'



# Regulatory Framework for Energy Efficiency in India

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- **Energy Conservation Act, 2001**
  - Created Bureau of Energy Efficiency
  - Appliance standards and labeling
  - Energy consumption norms, and energy-use reporting requirements for energy-intensive industrial units
  - Energy Conservation Building Code for commercial buildings
  - Certified Energy Managers and auditors
- **National Action Plan for Climate Change, 2008**
  - National Mission on Enhanced Energy Efficiency provides mandate for market-based mechanisms to promote energy efficiency

# INDIA -- NATIONAL ACTION PLAN FOR CLIMATE CHANGE (NAPCC) – 2008

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- **National Solar Mission (NSM)**
  - **Grid Parity**
  - To achieve volume production at a scale which leads to cost reduction and rapid diffusion and deployment of solar technologies across the country
- **National Mission on Enhanced Energy Efficiency**
  - **Scale Up**
  - Provides mandate for market-based mechanisms to promote energy efficiency
  - Industry, buildings, and power supply: Financing for each

# NSM : PROPOSED ROAD MAP



Sr No	Application	Phase I ( 2010-2013)	Phase II (2013-2017)	Phase III (2017 – 2022)
1	Utility grid power including roof top	1000 – 2000 MW	4000 – 10,000 MW	20,000 MW
2	Off-grid solar applications	200 MW	1000 MW	2000 MW
3	Solar collectors	7 million sq meters	15 million sq meters	20 million sq meters

# Renewable Energy Feed-in Tariff CERC Norms



Sr No	RE technology	Tariff (Rs/kWh)
1	Wind	3.75 – 5.63 ( based on wind zone)
2	SHP	3.35 – 4.62 ( based on plant capacity & location)
3	Solar PV	18.44
4	Solar thermal	13.45
5	Biomass power	3.83 – 5.42 (based on location)
6	Non fossil fuel based cogeneration	4.16 – 5.62

# End-use Applications



Source: IIT Madras

## Competing technologies –

- Lighting – Kerosene lamps
- Cooking – Wood, coal, etc.
- Water-heating – Electricity, LPG, etc.



# RE – Technologies India Needs Examples

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- Gasification of agricultural waste to generate both fuel gas and electricity to village grid.
- Higher ambient temperatures in India adversely affect thin film PV performance. Need performance characterization studies for India, (e.g., Rajasthan's desert regions)
- Land transportation of large wind turbine blades over roads and bridges is an issue.
- Need low wind speed turbine R&D
- Water availability central solar thermal -- Need for R&D on desalinization technology
- Combined water heating and PV

# **Future Energy Use in India – the inevitability of energy efficiency**

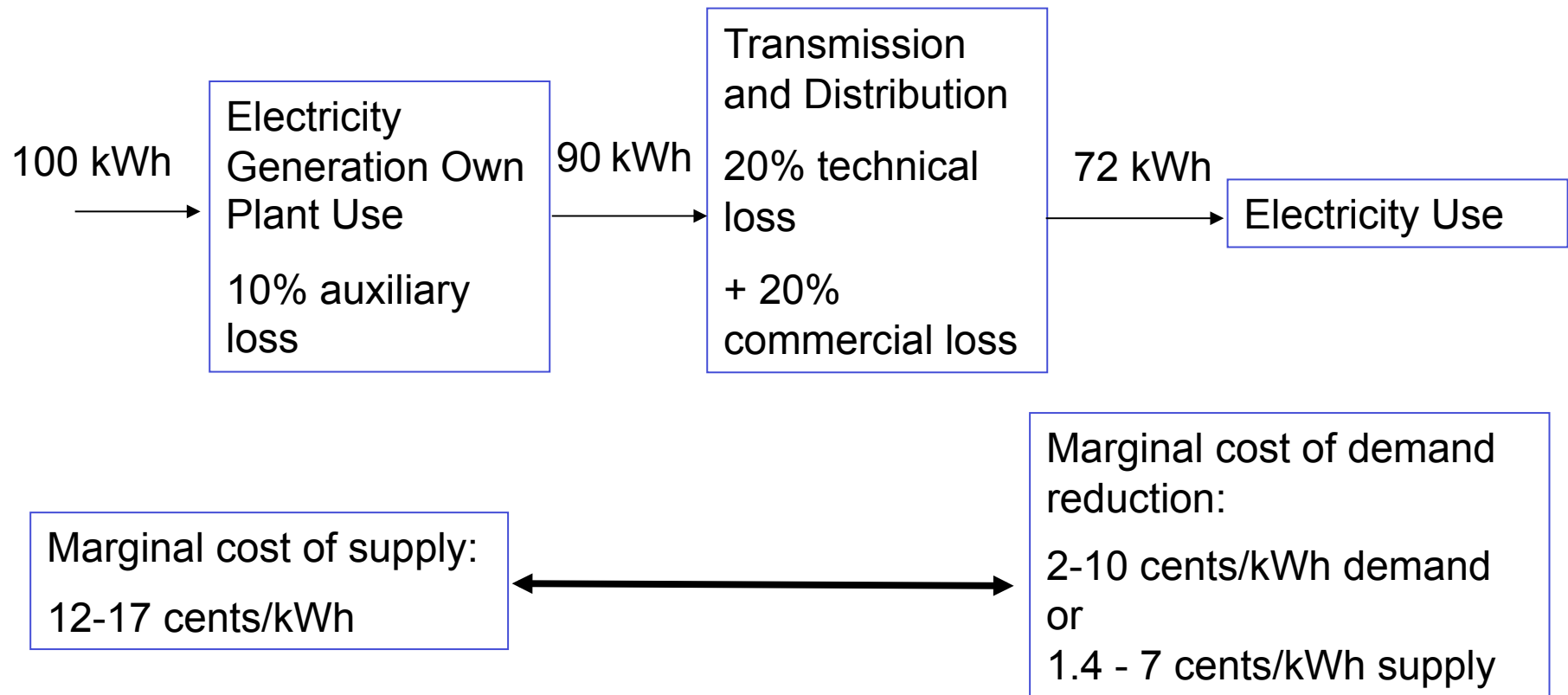
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- **Energy demand is increasing due to rising incomes, accelerated industrialization, urbanization and population growth**
    - 2003-04 : 572 Mtoe
    - 2016-17 : 842-916 Mtoe
    - 2026-27 : 1406-1561 Mtoe
  - **Fossil energy supply is expected to peak at about three times the current consumption**
  - **Vast fraction of infrastructure is yet to be built – opportunities for cost-effective, low-carbon options**
  - **Energy efficiency and renewables are key ingredients of a green energy future**
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# Utility Return on Investment: Typical India Values

“negawatts” win



**Efficient Use: Lower cost and shorter lead time than new supply**

## **Energy Efficiency Benefits in Electricity Shortage and Subsidized Tariff Conditions**

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### **Increased penetration of energy efficiency options can:**

- **Eliminate electricity shortage**
- **Reduce**
  - Carbon emissions
  - Import of fossil fuel resources—coal and natural gas
  - Agricultural subsidy payments for ground water pumping—\$10 billion a year
- **Increase output, employment, and tax payments due to**
  - Full supply of electricity to business customers

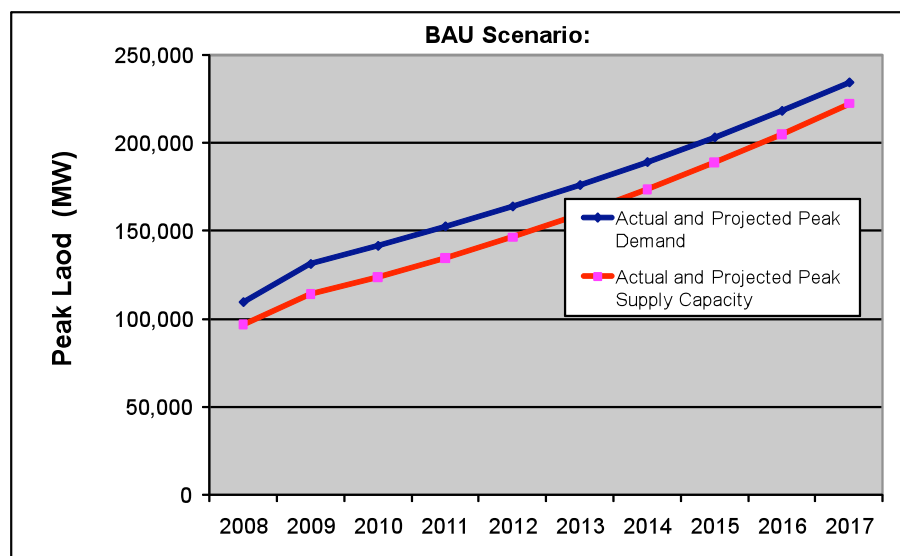
# Efficiency Scenario with No Shortage: Selected Efficiency Options

<b>Sector</b>	<b>Energy Efficiency Options</b>	<b>Investment (\$/kW)</b>	<b>Lifetime (years)</b>	<b>Daily Use (hours/day)</b>	<b>Peak Load Coincidence Factor</b>	<b>Savings (kW)</b>
<b>Res.</b>	<b>CFLs</b>	<b>50</b>	<b>2.7</b>	<b>4.0</b>	<b>25%</b>	<b>75%</b>
<b>Res.</b>	<b>T-5 FTLs**</b>	<b>125</b>	<b>2.5</b>	<b>4.0</b>	<b>25%</b>	<b>50%</b>
<b>Res.</b>	<b>Refrigerators</b>	<b>850</b>	<b>10</b>	<b>8.0</b>	<b>100% @33% load factor</b>	<b>30%</b>
<b>Res.</b>	<b>Fans</b>	<b>534</b>	<b>10</b>	<b>8.0</b>	<b>25%</b>	<b>10%</b>
<b>Comm.</b>	<b>T-5 FTLs</b>	<b>125</b>	<b>1.3</b>	<b>7.9</b>	<b>75%</b>	<b>50%</b>
<b>Ind.</b>	<b>Motors</b>	<b>275</b>	<b>15</b>	<b>5.8</b>	<b>25%</b>	<b>5%</b>
<b>Agri.</b>	<b>Water Pumping</b>	<b>195</b>	<b>15</b>	<b>4.5</b>	<b>25%</b>	<b>30%</b>
<b>Muni.</b>	<b>Public Water Pumping</b>	<b>171</b>	<b>15</b>	<b>6.9</b>	<b>50%</b>	<b>10%</b>
<b>Muni.</b>	<b>T-5 FTLs</b>	<b>125</b>	<b>1.3</b>	<b>7.7</b>	<b>50%</b>	<b>50%</b>

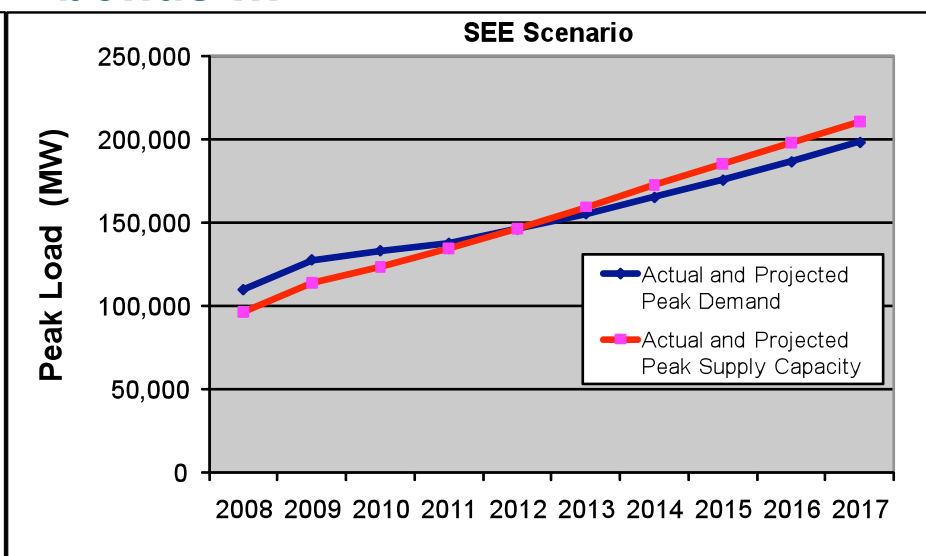




## BAU Scenario 1: Invest in supply capacity, but shortage continues



## EE Scenario 2: Invest in efficiency, eliminate shortage by 2016 – plus bonus ...



	BAU Scenario	EE Scenario
<b>2017</b>	6% Deficit	5% Surplus
<b>Capex (2009-2017)</b>	Rs. 390 thousand crores	Rs. 380 thousand crores (incl. efficiency options)
<b>Efficiency Options</b>		Lighting, fans, refrigerators, motors, agricultural and municipal water pumping



# Macroeconomic “bonus” from efficiency: Rs.2.4 million crores (\$500 billion) growth from improved productivity

## 2009-2017 Cumulative Benefit

Removal of  
Electricity  
Shortage to  
Consumers  
(358 TWh)

Removal of  
Electricity  
Shortage to  
Producers  
(246 TWh)

Low  
Electricity  
Intensity of  
Productive  
Sectors

**GDP  
Cumulative  
Benefit: Rs.  
2.4 million  
crores**

Excluding > 50% of producers that have generator sets and inverters.



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**Plus ....**

- **Carbon reduction bonus:  
312 million metric tonnes CO2  
reduced (cumulative) 2009-2020**
- **Reduced import of coal and natural  
gas – Rs. 42.3 thousand crores  
(US \$9 billion)**

# **Energy Efficiency -- Technological change is the key**

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- **Installation of energy-efficient infrastructure, equipment and appliances is essential for**
  - Meeting energy demand
  - Managing energy security, and
  - Meeting climate goals
- **Technological transitions – both deployment and development - are important in**
  - Power generation
  - Industry
  - Buildings, especially commercial buildings
  - Equipment and appliances
  - Mobility

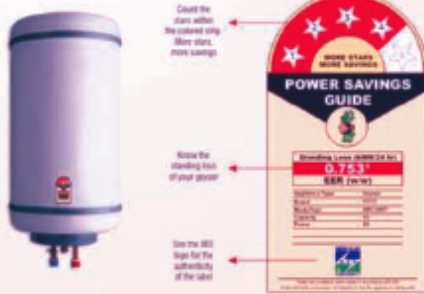
# Schemes for Promoting Energy Efficiency in India – 2007-2012

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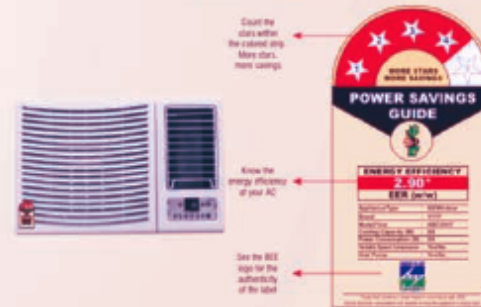


- House Hold Lighting
- Commercial Buildings
- Standards & Labeling of Appliances
- Demand Side Management in Agriculture /Municipalities
- SMEs and Large Industries
- Capacity Building of SDAs

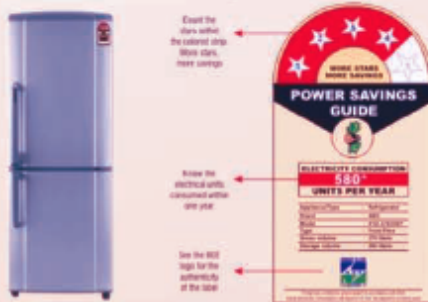
## Label For Electric Storage Water Heaters (Geysers)



## Label For ACs



## Label For Refrigerators



## Label For TVs



## Label For Ceiling Fans

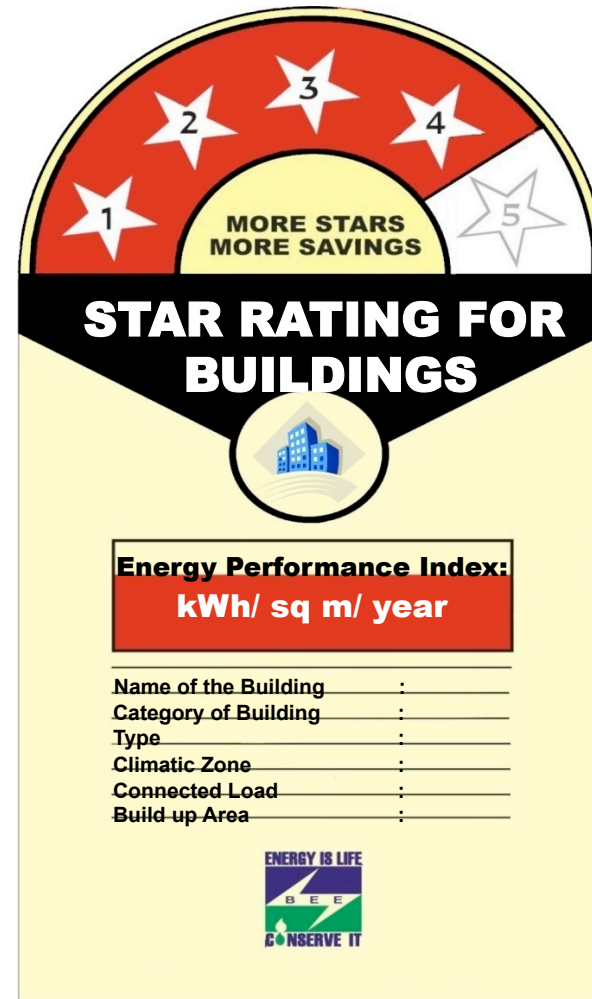
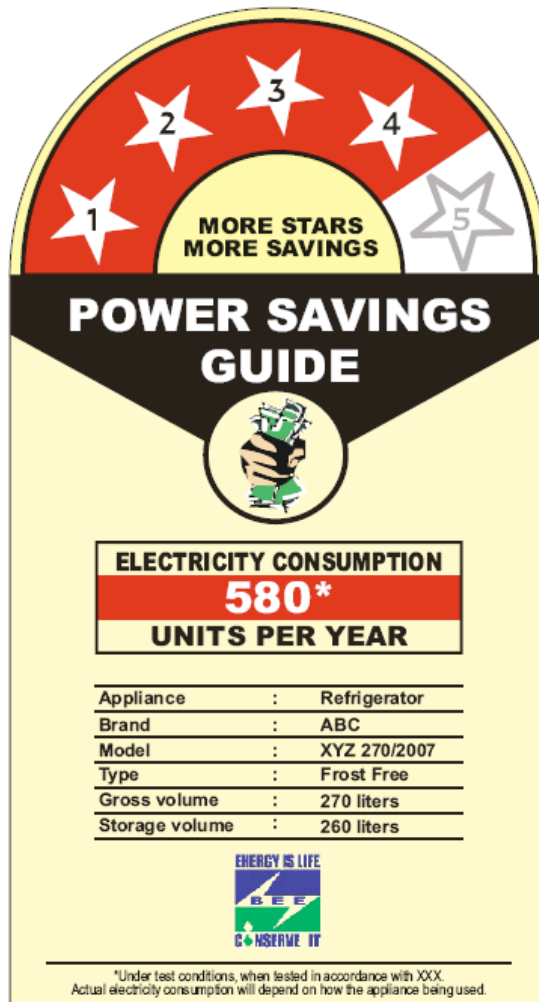


## Label For Tube Lights



# Labeling Program

# Information helps consumer decisions



# Labels built up as a “brand”

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- Voluntary labels for refrigerators and air-conditioners introduced in December 2006
- Aggressive advertising and outreach promoted labels as a brand of superior products – manufacturers piggybacked on label advertising
- In 2008-09, 75% of refrigerators, and 50% of air conditioners sold in the market were labeled – showing consumer preference and market transformation
- Labeling became mandatory for four products (where market transformation is well under way) from yesterday (7<sup>th</sup> January, 2010)
- Voluntary labels in place for six other appliances



# India Energy Conservation Building Code (ECBC) and Other Programs



Program	Organization	Compliance Req'd.	Building Type	Building Size	Scope	Linkage to ECBC
ECBC	Ministry of Power/BEE	Voluntary	Commercial	Connected Load $\geq 500\text{kW}$ Contract Demand $\geq 600\text{kVA}$	Energy Efficiency	NA
LEED-NC	Indian Green Business Center	Voluntary	Commercial/ Institutional	-	Sustainable design/green building	Refers to ECBC for energy efficiency credits
GRIHA	MNRE	Voluntary	Residential/ Commercial/ Institutional	-	Sustainable design/green building	Refers to ECBC for energy efficiency credits
Environmental Clearance	Ministry of Environment & Forests	Mandatory	Commercial/ Residential	Built-up area 20,000 to 150,000 Sq. Mt.	Environmental Impact	Refers to ECBC

# Perform, Achieve & Trade (PAT) Mechanism

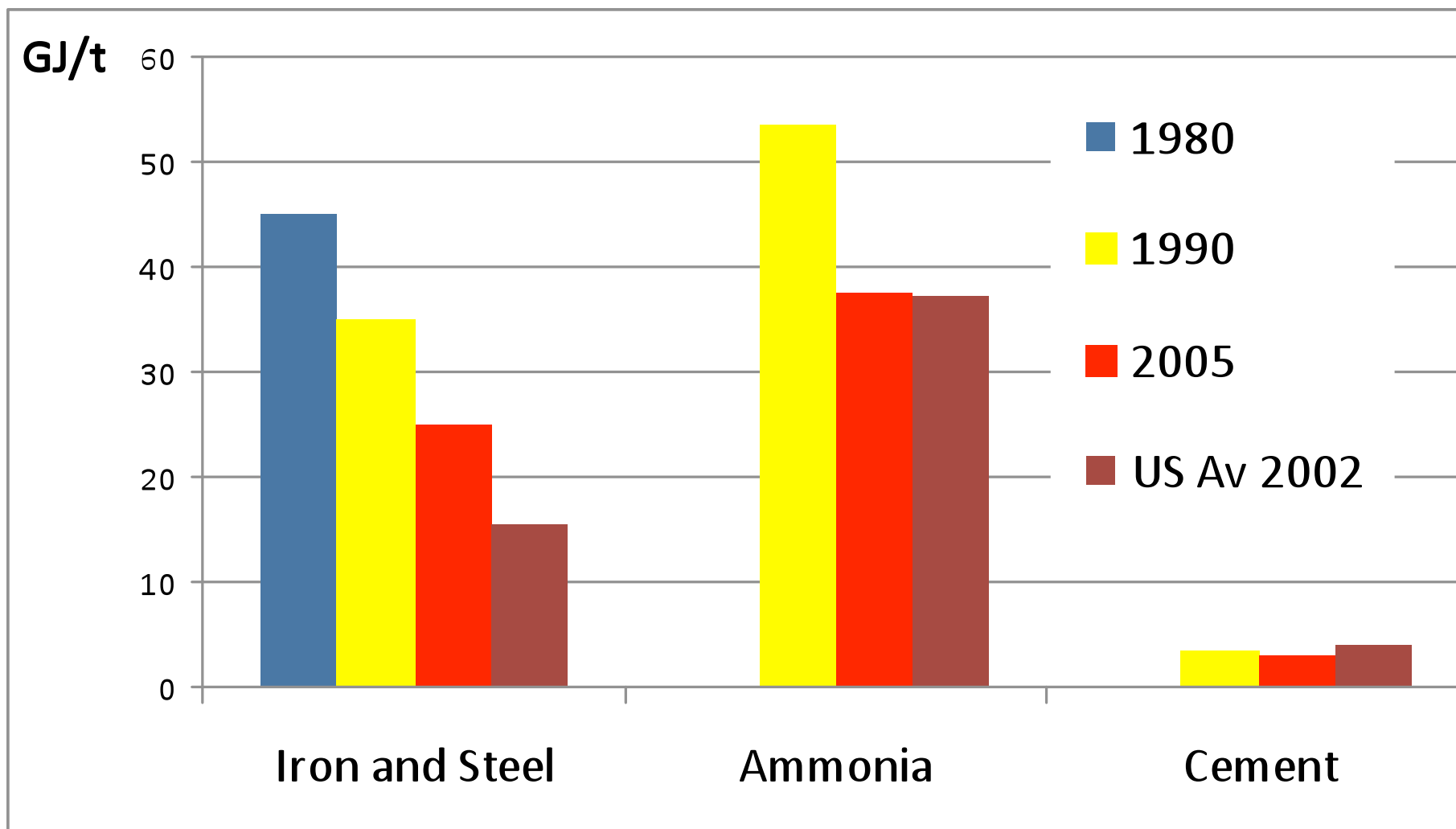
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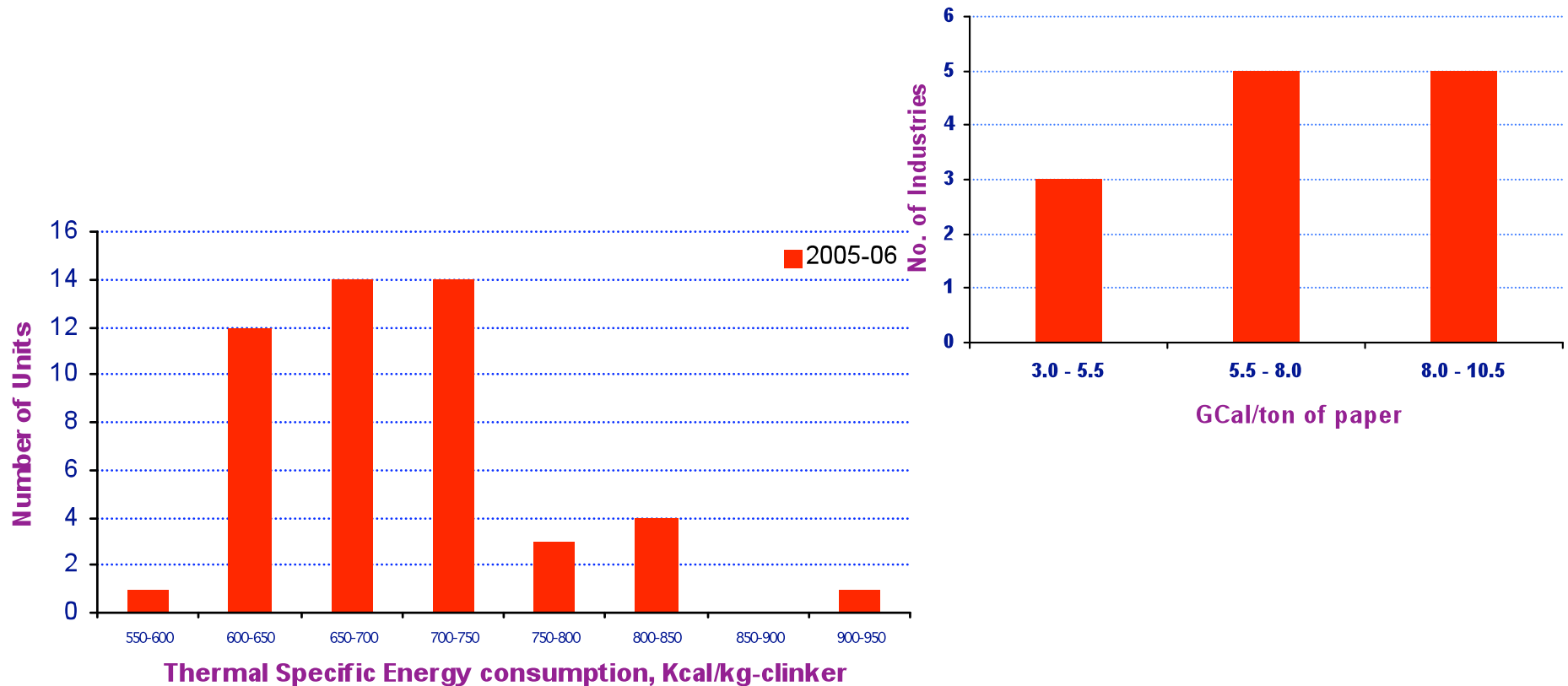
- **Specific Energy Consumption (SEC) reduction targets for the 714 energy-intensive units which are designated consumers under the Energy Conservation Act**
  - Targets would be percentage reduction of current SEC
  - Percentage reduction requirement based on:
    - Current SEC as a ratio of the best in the sector
    - Mix of fuels used
  - Target setting for the power generation and fertilizer sectors through the existing tariff-setting processes
  - SEC measurement and verification by BEE through accredited auditors

# Energy Intensive Industries Improvement

## Several Indian Industrial Sectors Are on Par with Global Best Practice



# Huge Diversity in Specific Energy Consumption within sectors



- Large bandwidth in specific energy consumption in all sectors
- In almost every sector, the most energy-efficient unit is also amongst the most efficient units in the world



## 2<sup>nd</sup> Energy Efficiency Technology Cooperation Conference

### Theme Paper : Energy Efficiency and Sustainable Development

Potential for US-India Collaboration in Buildings, Industry and the Smart Grid



16 & 17 November, 2009  
New Delhi



Confederation of Indian Industry



## Energy Efficiency and Sustainable Development

Potential for US-India Collaboration in Buildings, Industry and the Smart Grid

Jayant Sathaye, Ranjit Bhavirkar, Stephane de la Rue du Can, Girish Ghatkar,  
Maithili Iyer, Eric Masanet, Lynn Price, Ed Vine

Berkeley India Joint Leadership on Energy and Environment  
Lawrence Berkeley National Laboratory  
Berkeley, CA

and

Satish Kumar and Ravi Kapoor, ECO III  
S. Padmanaban

US Agency for International Development  
Delhi, India

November 2009

LBNL's contribution to this study was supported by the Office of Energy Efficiency and Renewable Energy, US Department of Energy under Contract No. DE-AC02-05CH11231.

# Buildings Energy Use Activities

## Capacity Building, Technical Assistance, and Technology Transfer



- **Technical Assistance on Buildings for IT Industry:**  
Providing technical assistance to multi-use IT office parks including Specialized Economic Zones (SEZs). Target projects include: Infosys, Metro Valley, and GreenSpaces, and Paharpur Business Centre. Transfer recent research and best practices to the Indian market via these showcase projects.

• **Assist BEE and USAID ECO-III in the development of benchmarks for energy use in buildings:** The above organizations have issued a star label for office buildings recently. LBNL reviewed the draft document and provided comments and suggestions for improving the building categorization and benchmarking methodology based on its experience in the US and other countries. This task will help the two organizations noted above to expand benchmarking to other types of buildings in India.

• Initiated new project in 2010 – **India Sustainable Cities Initiative** -- to analyze and evaluate buildings energy use and potential savings in key Indian cities and report on ways to establish programs and policies to accomplish the projected reductions.



Indoor Air Quality measurements at Paharpur Business Center, Delhi

Infosys's newest Green Building at the Hyderabad campus



# Buildings Energy Use (Continued)



- **Data Center Energy Efficiency:**

- Data centers are large energy consumers, especially in India where high tech industry is growing. In fact, energy use in data centers is growing at 30%/year per CII. This project, working with the Indian Government and Industry aims to support a national initiative to improve energy performance in data centers.
- Focus group meetings in New Delhi and Bangalore conducted in September.
- Feedback to DOE and BEE

This best practice tip sheet has been adapted by Indian agencies from “A Quick Start to Energy Efficiency” developed by LBNL.



Data Center in Bangalore to study gaseous contamination and corrosion issues.



# White Roofs—Albedo Effect



Albedo Effect: 100m<sup>2</sup>(~1000 ft<sup>2</sup>) of a white roof, replacing a dark roof, offsets the emission of more than 10 t CO<sub>2</sub>



United States



India

- LBNL conducted a one year experiment at Satyam Computers Training Center in Hyderabad, India in 2006-07 → up to 20% reduction in AC load due to white roofs
- Delhi Chief Minister approved mandatory white roofs for all new government buildings in July 2009
- Surabi Menon and Art Rosenfeld are leading a new effort



# Demand Side Management (DSM) Programs

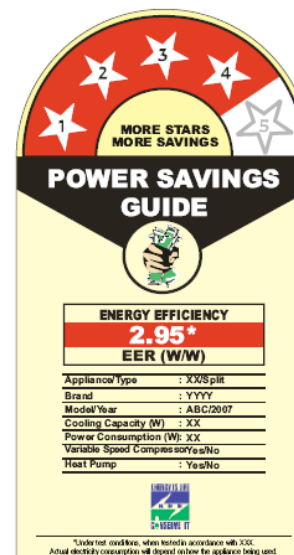
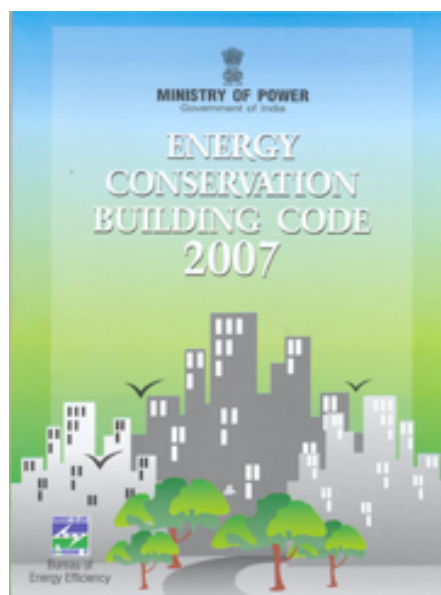
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- **State-level DSM programs**
  - US ~20 states; India ~ 5 states
- **Multi-state (RMSDP) or national DSM programs**
  - Under implementation in India
- **International and global programs – SEAD**
  - India, US, Australia, Japan, Korea, UK, ++

# Progress So Far ...

- \$25 Million: India's first utility-scale efficiency program in Maharashtra; April 2008
- \$10 Million: Delhi's first efficiency program; June 2009
- Assisting Bureau of Energy Efficiency (BEE) and Forum of Regulators (FOR) to implement multi-state DSM and efficiency programs



**Next: West Bengal, Karnataka, Punjab, Gujarat, Madhya Pradesh, Chhattisgarh...National... International**



# EnergyPlus GUI Project

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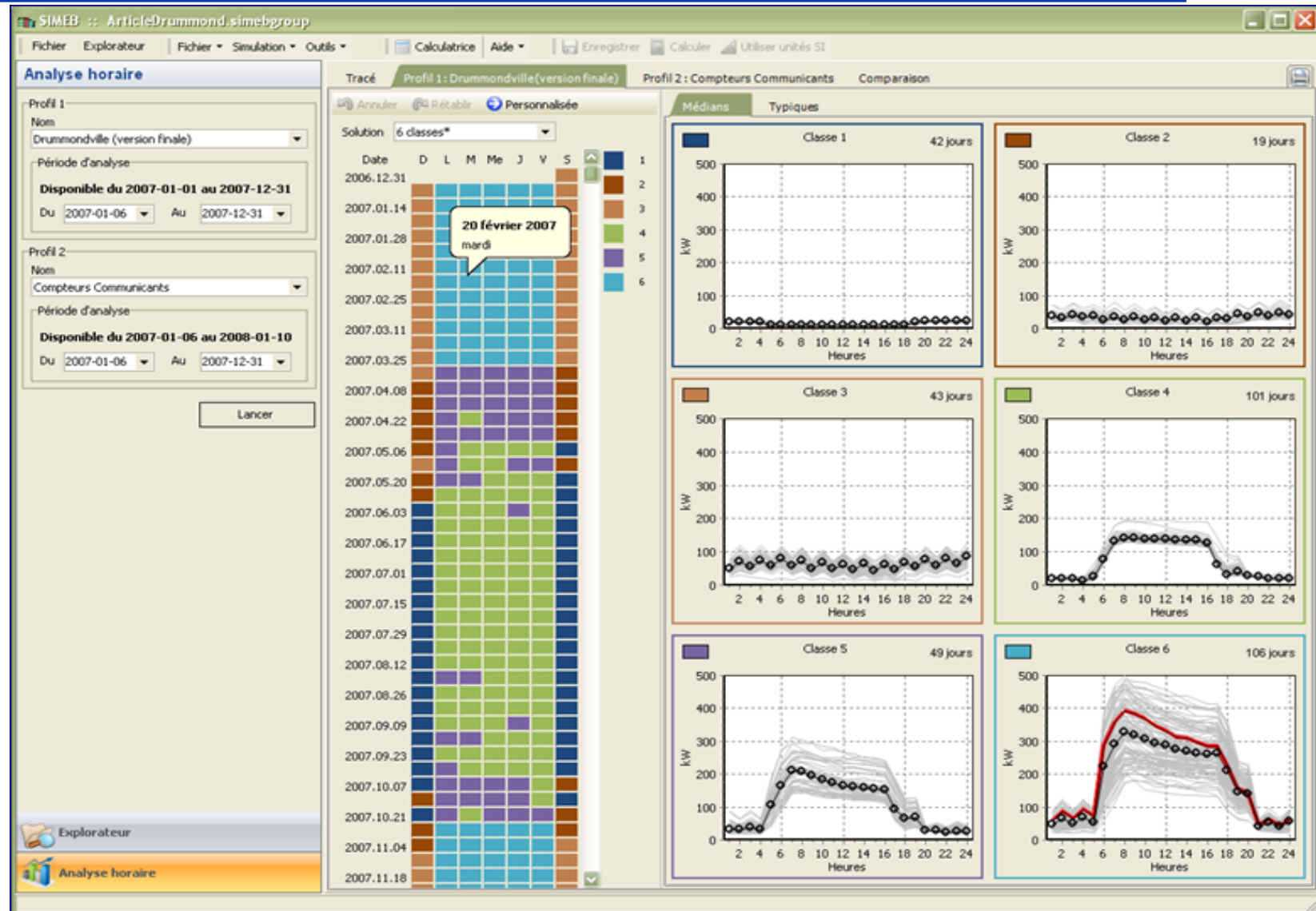
## Goals

- **Develop a free Graphical User Interface that enables EnergyPlus to be used more easily and effectively by building designers and other professionals**
- **Distribute as an “Open Platform” with well documented API’s to facilitate collaborative development and derivative works**

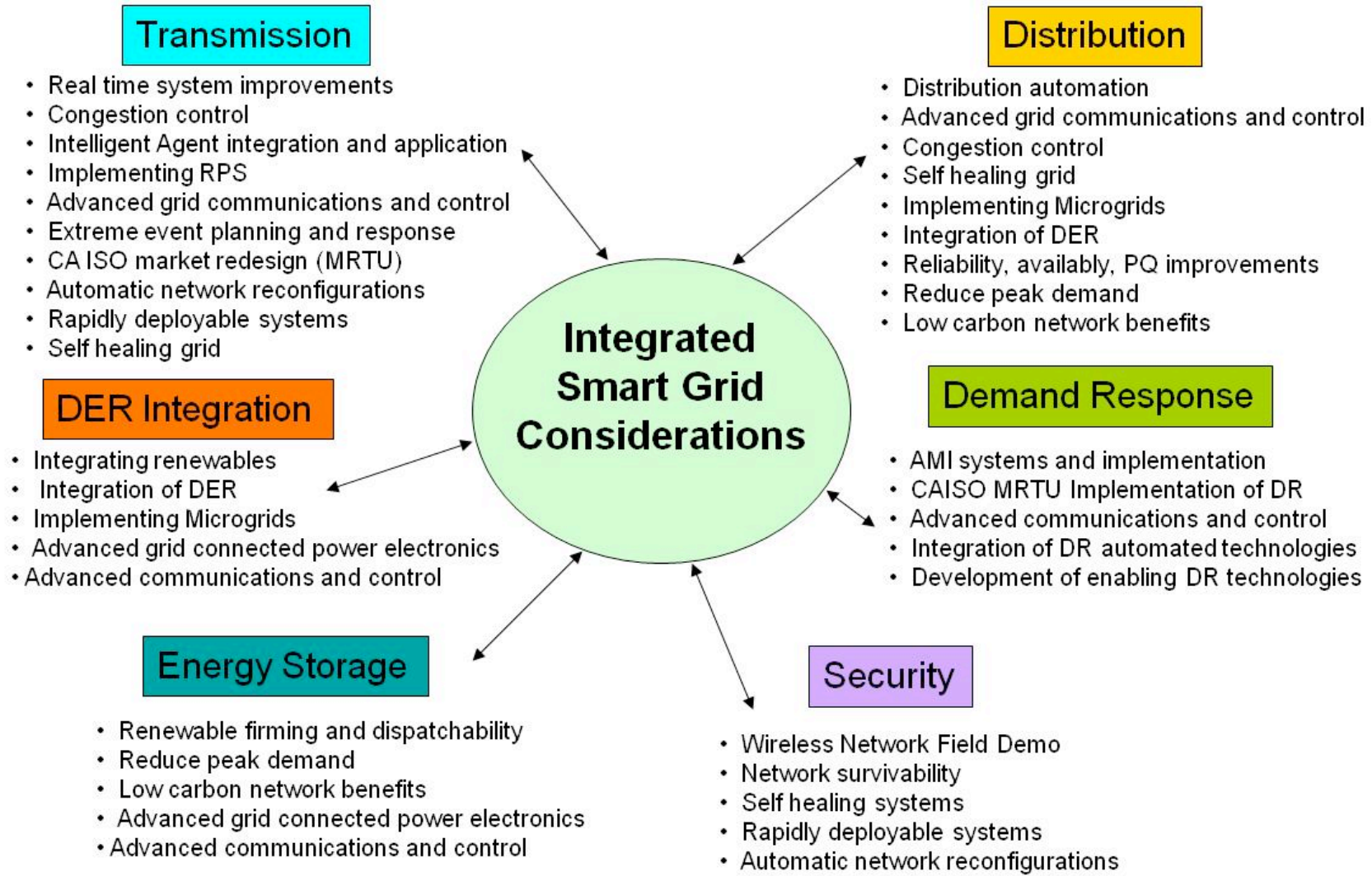
**Funded by: CEC, DOE and Infosys Technologies**

**Team: LBNL, Infosys, Digital Alchemy, Arup, GARD, Taylor Eng.**

# Output Visualization



# Smart Grids

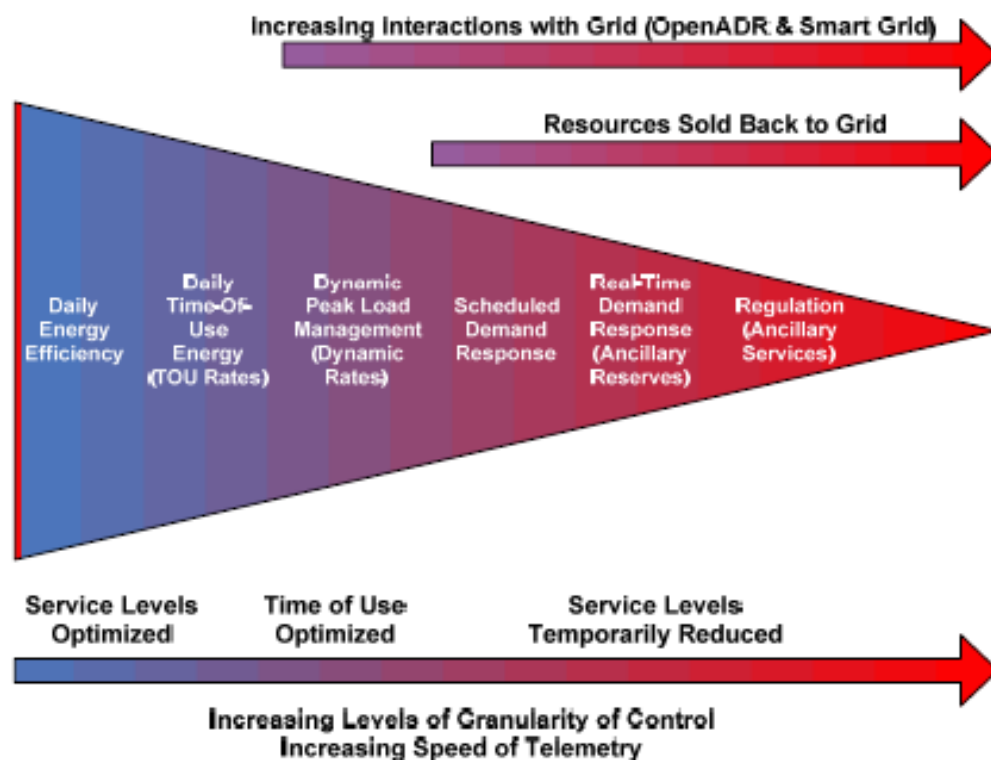




# Smart Grids and Branding Activities



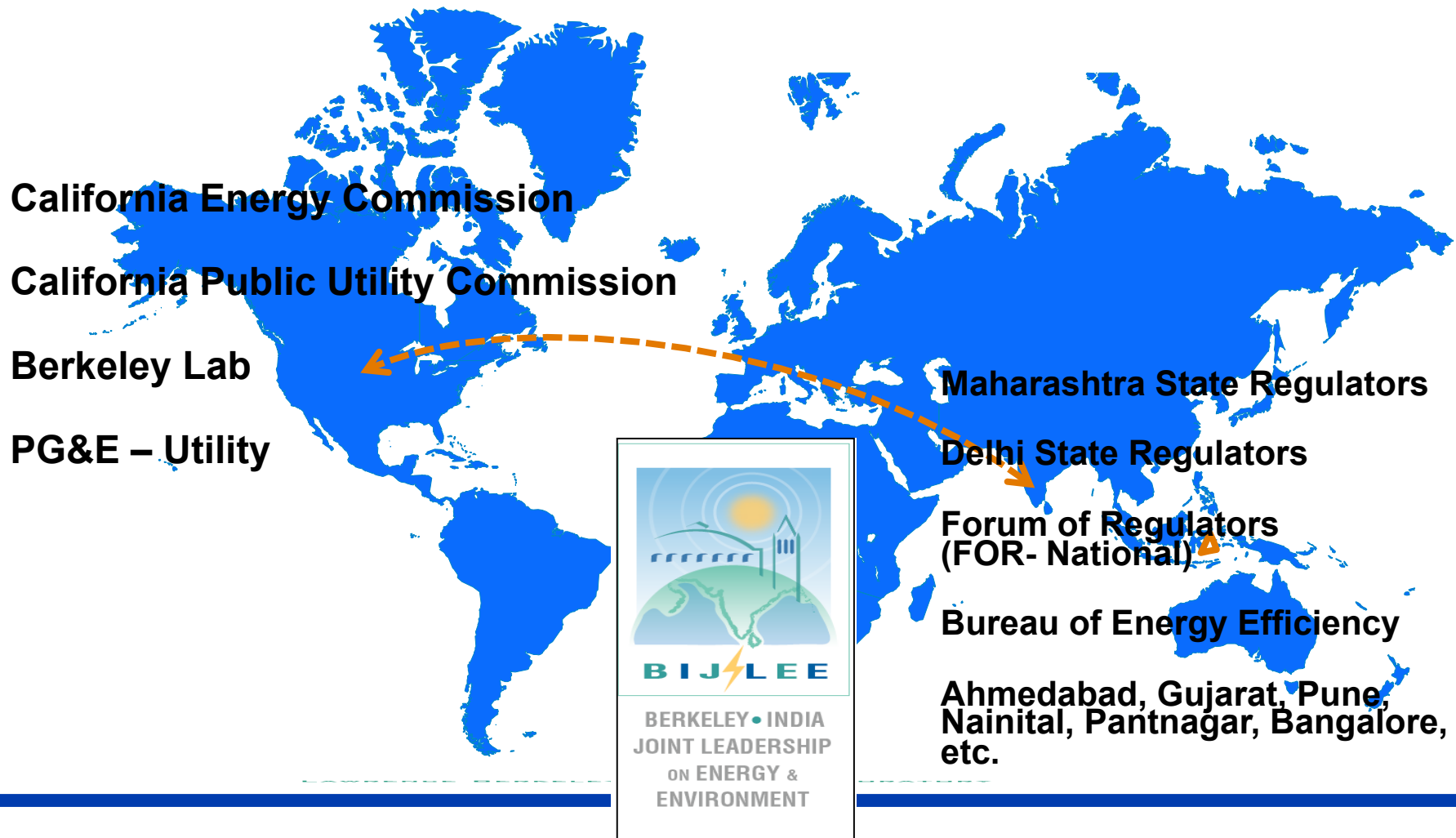
- Smart Grid and DR: Proposed work with US and Indian public and private entities on potential broader initiatives that includes Smart Grids and DR and create a long-term roadmap that addresses electricity reliability, security, and congestion; and power quality issues in India. Engagements with Indian entities such as Ministry of Power, research organizations are being pursued for potential US-India collaboration.



# Sharing what works: National, State and City MOUs —

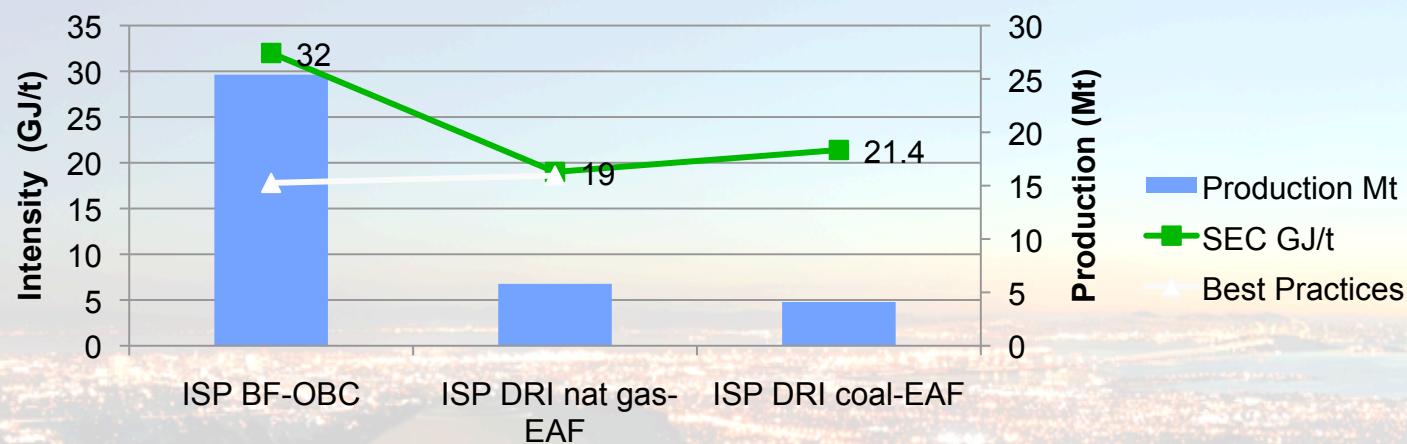


## USDOE-India Ministries of Power, New and Renewable Energy and Urban Development





## Integrated Steel Plants



## Small Scale Steel Plants

